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# THE JOURNAL OF PHILOSOPHY

## PSYCHOLOGY AND SCIENTIFIC METHODS

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### ILLUSIONS OF DIRECTION ORIENTATION<sup>1</sup>

THE consciousness of the cardinal points of direction is a subject that has not received the attention which its practical bearings in orientation justify. Mr. Townbridge has pointed out that two fundamental methods of orientation are employed.<sup>2</sup> The method

<sup>1</sup> This paper was read before a number of my colleagues in the department of philosophy and psychology. In the discussion which resulted it became evident that some of the experiences and difficulties here described are foreign to individuals who were brought up in childhood in cities. These individuals acquired the habit of orienting themselves with respect to certain conspicuous buildings and streets and thought very little of the cardinal points of direction. One reports that the terms east, west, north, and south had a much more particular meaning to him than they did to me. To him as a child the east side of the city (Chicago) was merely the side on which the lake was located; west meant the other side. To such individuals, it appears, the names of the cardinal points have been associated with domi-centric orientation in a purely practical way, and this habit has become so fixed that the persons in adult life on going into a strange city at once establish similar practical associations with very little reference to the sun, or to the cardinal points of direction. Their orientation seems to remain largely domi-centric, to use the term in a wide enough sense to include the sort of practical adjustment just described. My own early experiences were in a country, on a farm, where mountains were constantly visible even to distances of over fifty miles. The practise was to determine the time of day, especially noon, by the position of the sun. The north star early became a familiar friend and guide in the night time. In hunting-trips extensive cross-country excursions were frequently taken both in the daytime and in the evenings when stars were the safest guides as to direction. It is possible, therefore, that the cardinal points of direction have become much more important guides to me in later orientation in cities than to many of my readers. From our discussion it appeared that individual differences of this kind are largely due to early training. If this proves to be the case will it not make even more emphatic the need of attention to orientation in early geography teaching? For more consistency in one's larger geographical conceptions, and for the purpose of preserving a broader intellectual interest in the geographical and astronomical aspects of nature, is it not a good thing to emphasize the ego-centric orientation in the child's early education? Because of these individual differences this paper must be regarded as merely preliminary. It is hoped that opportunities will be afforded for a more extensive study of this subject in the near future.

<sup>2</sup> "On Fundamental Methods of Orientation and 'Imaginary Maps,'" *Science*, XXXVIII., 1913, pages 888 ff.

generally used by civilized man except in the immediate vicinity of his home is called the *ego-centric* method, because it is based on the intersection at the ego of the lines going out to the cardinal points of direction. The second method Mr. Townbridge calls the *domi-centric*. Orientation by this method is carried on with reference to an established central place, the "home." Birds, mammals, fishes and other animals, young children, and savages are said to employ domi-centric orientation, a method making possible considerable reflex development and the establishment of familiar paths and trails. The successful use of an ego-centric system of orientation implies considerable imagery. It gives only an indirect clue to the direction of the home or starting-place, requiring the individual, therefore, to image the general situation in the form of a map. This map, it should be noted, includes numerous points closely related by direct association. It is evident, therefore, that such a map-construction constantly involves, along with the consciousness of the points of direction, also something of the direct, or domi-centric, orientation. Ego-centric orientation is really, then, a complex of the two systems.

This fact of complexity of the system of orientation employed by adult man seems to lie at the basis of a confusion, as it appears to the writer, in the interesting paper to which reference has been made,—a confusion the clearing up of which will likely simplify the classification of types of errors in "imaginary maps" made by Mr. Townbridge. The confusion seems to be in the failure sufficiently to separate the elements of the domi-centric from those of the ego-centric behavior. Through early faulty instruction as to the direction of certain places, without any reference to the cardinal points, a child may develop a false notion of the direction of a city and yet not be confused as to what is north, south, east, or west. This notion may conceivably have a feeling of reality associated with it even though later experience may have proved it to be false. In such a case the person is not said to be "turned around"; that is, there is no general illusion as to the cardinal points of direction. The purpose of this paper is, however, not to enter critically into the classification of imaginary maps, as given by Mr. Townbridge, but to present further data on illusions of the sense of direction.

If an older child or an adult is asked at any time to indicate which direction is north he will usually be prepared to do so even though his north is not the true north. Many persons have a "feeling" that a certain direction is north when as a matter of fact they know that it is not. They operate on the basis of two ego-centric systems more or less contradictory. We might distinguish in this regard five types of individuals, or better, five types of consciousness of direction, all of which the same individual may experience under different circum-

stances. (1) Those whose consciousness of direction is correct; their north is the true north. (2) Those whose consciousness of direction is wrong and known by experience to be wrong; *e. g.*, what seems to be north may be known to be east. (3) The same as those described in the previous class except that the consciousness of direction is not known (has not yet been found out) to be wrong. This is an earlier stage of the second class. (4) A class early pointed out by Binet and called disorientation—those who are temporarily confused as to what *seems* north. This condition, of short duration, may be experienced on suddenly awaking in a strange hotel, or on a moving train. It may persist for some time if on a cloudy day one is on a train making frequent turns. (5) This type includes the animals, very young children, and probably savages, for whom no general sense of direction has developed. Orientation is domi-centric.

Normally this consciousness of direction has arisen so gradually and by so natural a process in our experiences that we are inclined to feel that it is an innate faculty, just as our moral conceptions were at one time thought to be due to an innate moral sense. It is, however, unquestionably acquired or gradually developed from data furnished by various of the senses, and is, therefore, not a sense at all in the meaning of an original faculty of the mind. It is nevertheless convenient in this paper to use the expression "sense of direction" if it is explicitly understood to be an acquired disposition. Illusions of orientation, or of the sense or consciousness of direction, are cases of disagreement between the person's perception, or general "feeling," of north and the true north.

From the results of observations of various reliable individuals it has been found that there is a tendency for the illusion of orientation to equal approximately 90 or 180 degrees.<sup>3</sup> The frequency of the 180-degree illusion has led certain writers to use the term "reverse" illusion of orientation. There are at least two reasons why the illusions tend to approximate one or two right angles. It is possible that illusions of but a few degrees are not as a rule noticed, as they cause very little confusion in behavior, especially when one is going across country where streets and the usual division lines are not visible. The writer has frequently noticed that under such conditions any direction within the limits of a considerable angle could be made to appear north, if attention were centered upon it with that purpose in view. Past experience with streets crossing at right angles, moreover, unconsciously emphasizes to us the cardinal points so that we habitually classify directions according to right-angle units of divergence from the north. Thus we describe objects as being nearly east, south,

<sup>3</sup> Binet, A., "Reverse Illusions of Orientation" (tr.), *Psychological Review*, Vol. I., 1894, pages 337-350.

west of south, southeast, always putting the emphasis on the names of the cardinal points. The very adoption of the directions north, east, south, and west as our cardinal points of direction makes it difficult for us to think in other terms, just as the custom of figuring in the decimal system of notation makes thought in any other system difficult. In ordinary thought no other system gets any consideration at all. When first one's attention is called to the possibility of any other plan of notation the thought is somewhat stupefying. Illusions that are noticed are thus unconsciously affected by our tendency to think of directions in terms of the cardinal points. If one has lived in a city the streets of which are laid out according to the cardinal points of direction, one finds in strange cities a strong tendency to see streets following other directions as if they also run north-south and east-west. Finally, illusions of direction ranging from 30 to 60 degrees are by no means wanting.

It is remarkable that in the extensive studies of perception which have been carried out the aspect of the orientation consciousness with which we are here concerned has received so little attention. This is likely because of its fundamental relation to all our spatial perceptions. Psychology has been busy largely with the study of the individual perceptive processes themselves. The various experiences in which each of us is constantly absorbed are given their significance and general setting by associations among themselves. As is true of the heavenly bodies in our firmament, the more remote experiences are likely, by virtue of their more numerous associations, to be the more permanent. Astronomy began with the observation of the more immediate and striking phenomena. In the history of psychology we have gradually been gaining perspective and have thereby more plainly seen the inadequacy of certain earlier views. In the realms of animal behavior, where the complete environment and past history of the individual are more easily observed and controlled, the question of orientation has in many cases received explicit attention, and has been the direct object of experimentation. Even here, however, the facts are relatively complex and as a consequence numerous theories of "distant orientation" have arisen. Hypotheses of a special sense of direction have not been wanting, although no one has attempted fully to show how such a sense might operate. Such an attempt seriously undertaken, even theoretically, would doubtless have had an effect here similar to that in ethics of analyzing the "moral sense" of Shaftesbury and Hutcheson.

There is good reason to believe that a general consistency in one's perceptions of direction is maintained, as is doubtless true of the continuity of self-consciousness, by a multiplicity of factors. This condition makes direct experimental tests difficult. A careful exam-

ination of a few striking cases of illusion of orientation, however, reveal in a measure some of the factors by which the general sense of orientation is maintained. In such an analysis it will be convenient to give the descriptions in a somewhat personal form.

In the summer of 1914 I experienced in Chicago an illusion of unusual vividness. In company with others I was transferring from a north-side to a south-side car. We entered our car as it was facing west just before the turn to go south. When this car started the other members of the party had become seated, but I was still standing giving our transfers to the conductor. The suddenness of the turn which the car made while my attention was diverted to the transfers and to the maintaining of my equilibrium in the standing position "turned me around" completely. When I took my seat the car appeared to be going north. I thought that we had taken a wrong car, but was assured by the other members of the party that we were going south. Of this fact I found further proof on passing certain familiar buildings, and on our arriving at the point where the car line takes a separate course from that of the elevated railway under which we had been moving. Having usually taken the elevated-railway car, I was not very well acquainted with the street along which we were now passing; moreover, as it was dark only a momentary and imperfect view of the familiar marks along the way was possible. The illusion therefore persisted. I saw streets known to lead on the east side to the lake, but which now appeared to go westward. We came finally, on Cottage Grove Avenue, to Washington Park on the right with which I was well acquainted. Not even this enabled me to correct the illusion. Immediately, however, on stepping out of the street-car on 58th Street and Cottage Grove, in the midst of numerous perfectly familiar objects and buildings I felt an "unwinding sensation" in the head, a sort of vertigo, and presto! the illusion was gone. I saw the car start its motion and continue in the direction in which it had been going—but now it was due south.

The sensation of so sudden a "change" is a peculiar one: the various present stimuli, bringing up innumerable familiar associations and attitudes suddenly force some sort of readjustment in one's general orientation attitude. It is a striking bit of evidence that we are not passive in our perceptions and interpretations, but that everything must be seen in some system of generally consistent relations. Coming with such an erroneous sense of direction into familiar surroundings, one experiences for a time a conflict of two different systems. Sometimes the change is gradual; occasionally, when, as in the present case, the conditions are favorable, it is sudden, with possibly even a feeling of being forced by the general surrounding ob-

jects and circumstances. This condition is in some respects similar to changes in personality.<sup>4</sup>

A second case of illusion of direction, which I have been observing for about three months, is more complicated. In certain sections of Minneapolis I am "turned around" to the extent of 90 to 100 degrees. It is not easy to determine the exact extent of the illusion, as any one will find who attempts such measurements. The extent of the illusion also varies for different parts of the city where the illusion is experienced. Though this illusion is readily dispelled when I go into certain parts of the city, or outside the city, it has been impossible for me to get rid of it in the parts of the city with which I first became acquainted. In these sections where the illusion prevails, viz., in part of south and of southeast Minneapolis, the streets are not laid off according to the cardinal points on the compass, but follow the general direction of the river. Having not been accustomed to this condition, though I have, of course, frequently met with it, I find a tendency to perceive the streets as having the more usual north-south and east-west directions. This tendency—which never quite prevails—is especially strong whenever I am in a house looking out of a window which offers a somewhat limited view. My knowledge before seeing the city of the irregularity of the streets, and the fact that my illusion when I came to the city was approximately 90 degrees, likely account for my not seeing the streets as consistently following the cardinal points of the compass.

Having left Omaha for Minneapolis in the night, I found myself "turned around" in the train in the morning. Cloudy and rainy weather made it impossible to right myself by the position of the sun, so the illusion persisted until we arrived in Minneapolis. The sun did not become visible for several days. In the meantime I had become acquainted in a general way with two sections of the city, the part of south Minneapolis between Tenth Street and the river, and Hennepin Avenue and Sixth Avenue South; and the part of southeast Minneapolis between the river and Eighth Street, and Central Avenue and Fourteenth Avenue, including the old campus of the University of Minnesota.

Three factors, then, evidently contribute to this illusion of direction: (1) The relaxation while asleep in a moving train, where bod-

<sup>4</sup>I recently witnessed the restoration by hypnotism of the personal memories of an individual who had completely lost his past experiences. An injury to the head in an accident was the cause of the disturbances. The person did not even know his name and could not recall his vocation or line of work. The change to a "self" with a good memory of numerous experiences of the past—which we found later, however, not to be the true self—and the return back to the "accident self" were immediately followed by peculiar movements and facial expressions of surprise, seeming to suggest an inner feeling of readjustment.

ily attitudes could have little chance of functioning in the maintenance of the sense of orientation even if one were on the alert;<sup>5</sup> (2) the formation of rather permanent associations of parts of the city with this erroneous direction attitude before it could be corrected by noting the position of the sun; (3) the unusual direction of the streets in the sections of the city with which these associations were formed. I had become so accustomed to streets following the cardinal points of direction that this one condition had become a fruitful means of orientation when the sun was not visible. One does not usually get the concurrence of so many factors favoring the illusion. When the sun did appear it was not a sufficiently forceful check—as was the sight of numerous familiar objects in the Chicago illusion—to correct the false system of associations. Moreover, these associations were in this case already more numerous and permanent than were those in the Chicago case. Of the other members of the family, R, an adult, experienced no, or but very slight, illusions of direction; K, a boy of eleven years, was “turned” about the same number of degrees, and in the same direction, as myself; while two small children, ages five and eight—the latter slightly retarded in development because of sickness early in life—seemed to orient themselves wholly on the domi-centric basis about the new home. Questions asked these two children as to the cardinal points of direction—such as “Which direction is north?” or “Show me which direction is north”—were to them artificial and called out only varying guesses. The methods by which these two children learned the way to certain stores and to school also confirmed the belief that their orientation was domi-centric.

In other parts of the city where the streets follow the usual direction of the cardinal points I experienced no illusion, if my visits to them were made while the sun was visible. This seemed true whether I walked or went in a street-car or in an automobile. Could the illusion, therefore, not be permanently dispelled if I noted carefully my directions along the way on my return? On several occasions I tested this logically plausible supposition. Regularly the illusion disappeared when I got outside of the sections visited on my first (cloudy) days in the city. Usually the disappearance was so gradual that its exact time and place could not be noted. At certain places in the borders of these sections there was much uncertainty experienced as to just what really did seem north! Sometimes on returning I approached by some particularly new way so near the region of the illusion that I fully expected to see it forced

<sup>5</sup> The importance of a general bodily orientation has been experimentally demonstrated by E. Mach, “On Sensation of Orientation,” *Monist*, 1897, though he does not apply the experiment to direction orientation.



away completely, as was done in the Chicago case just given. At one time, returning from the state fair grounds on the street-car, I had come so near to the area of the illusion with the correct sense of direction preserved that the car had to make but a single turn—a distance of three to six rods. I remember saying to myself: “Now there is a surprise in store for me.” I expected to see the university grounds, which were near at hand, in their true position with respect to direction. But suddenly as the car turned the whole “ground” gained seemed to slip—and the old erroneous view returned. No vertigo was experienced, but there was a decided feeling of discouragement: the situation seemed too big to be controlled without some sort of bird’s-eye view of the surroundings. At this time, and also at the times of the following experiments, I had with me a small pocket compass which I had purchased with the view of correcting the illusion.

An example of the gradual change is interesting. On August 26, 1915, I walked to Seventh Street on Hennepin Avenue. By the time this point was reached my sense of direction was shown by the compass and by the position of the sun to be approximately correct. I began my return from this point at about 2:30 P.M., the exact time not being noted. On the return I walked toward the northeast, and the shadow was consequently cast nearly straight ahead, *i. e.*, in the direction I was walking. Before crossing the river I turned slightly to the right, or slightly more to the east than I had been walking. Some distance beyond the river, at Fifth Street on Central Avenue, the street turns approximately 30 degrees nearer toward the north, or to my left, taking a direction somewhat north of northeast. Each of these turns confused me slightly, so that I could not determine exactly just what did seem to be north. Occasionally I felt that my sense of direction was about right; again, when I tried to think of the relation of the street I was on to southeast Minneapolis, it would seem to be considerably wrong, my north being placed too far toward the east. I expected, however, to make a considerable correction on my illusion as I could approach the “dangerous” section gradually and constantly check up by the position of the sun and by the compass. At Seventh Street on Central Avenue, which I was following, there is a sudden turn of about 90 degrees to the east, to my right, giving me a direction somewhat east of southeast. This was the critical point. If this turn could be made successfully I should be victorious. All that I had gained, or held up to this point, slipped away gradually, however, as I saw the familiar scenes from Fifth to Seventh Streets. At such times one has a peculiar feeling of helplessness. Before reaching the point of this change I could imagine myself at some elevated point seeing the streets lead off from Central Avenue at 90

degree angles, and could consistently image them as following a south-westerly direction. But to proceed I felt was to lose all that had been gained.

Under conditions of such illusions of direction it is incredibly inconvenient to think of the larger divisions of a city and to try to get a consistent view of the whole situation. This is especially noticeable if a stranger asks you for directions to a place in the city outside the area in which you orient yourself in the domi-centric manner. It is the demands of a general social consistency that makes an erroneous attitude or perception so distressing and its correction so urgent. In certain parts of a city one can soon build up a workable domi-centric system for orientation; but when conformity to the activities and conceptions of others is demanded, or when one goes to the map for general directions to more distant points, then trouble arises. While the map is useful in studying the general features of the city, giving relations of one part to another, one finds it necessary to turn it according to one's own direction sense if one is going to some remote part of the city. While the map shows the university to be southeast of my residence, I continue to find it necessary to walk toward the northeast to get it! But suppose that I want to go to some place due east or north of the university, then I am ridiculously confused.

These experiences bring to mind the need of careful attention in the child's geography lessons to the development of the consciousness of direction. I have found that because of the irregularity in the plan of the streets of Minneapolis many of its citizens of long terms of residence have two systems of direction, one that is *known* to be the true one and one that *appears* to be the correct one. This has been found also to be the case in other such cities. Certainly such a condition is sufficiently important to demand the careful attention of public-school teachers. In the arrangement of rooms and of other means for the teaching of geography certain general principles in the development of the sense of direction should be kept in mind. Great aid may also be derived by having certain students carry a small pocket compass which can be had, with the necessary accuracy for practical purposes, for a nominal price.

There are evidently a number of similarities between the development and maintenance of the sense of direction and the development and continuity of personality. Both are dependent upon a multiplicity of factors all of which tend in either case to build up and preserve a practically permanent and comprehensive attitude. The absolute permanency of the self, maintained by the older philosophers, is likely a fiction: the self is gradually changing. Its memories, its likes and dislikes, its acquaintances, its intellectual tastes, its ideals, and its very self-thought are all changing as truly as anything in our

world of living forms. But there is a general continuity throughout these changes. The high degree of constancy of our surrounding physical stimuli, of our own physical appearance, of the names by which we are known, of the attitude of friends toward us, of various social institutions, of spoken and printed language—all these stimuli, and many more, are constantly tending to maintain for us one general attitude, one personality. This personality has, however, many variations, and may by unusual circumstances of disease or accident suffer profound disturbances. If under such circumstances a new personality emerges, it is necessary for the prevention of its permanency to see that the external conditions, social and physical, be made constantly to change as much as possible so as to prevent the establishment of lasting associations.<sup>6</sup>

So we find it also in the case of the changed sense of direction. The first few moments are crucial. Almost any one has likely been momentarily "turned around" in some new place and then has been set right by certain familiar marks, as the sun, the north star, or the sight of some distant mountain. As soon as a person finds that he is "turned around" even to a small extent, it is necessary that he at once take steps to correct the erroneous perception. There are times when this is for the moment impracticable. If at such times the person is on a moving train, or amid surroundings which are constantly changing, there is no need of any anxiety: the associations under such conditions can not become permanent. If, however, the erroneous attitude is seen to persist rather consistently even amid the constantly changing conditions, then it is highly probable that any cessation of these conditions will leave the person "turned around." Such consistency in the illusion is most likely to develop during a night's sleep on the train. On leaving the train and going into a strange city it is worth while to bend every effort toward dispelling the illusion. In this undertaking the following suggestions may be of value: If the sun is not visible the true north should be determined as accurately as possible. For this purpose it is a good thing to have, when traveling, a pocket compass. Other means are available, however. If the direction ascertained to be the true north does not appear to be north, the person should avoid as much as possible going out into the city. On going to one's hotel it would be well to take as little note of general directions as possible, so that erroneous associations will not be too firmly established. Once inside the building, however, where some time is to be spent, it would seem advisable to ascertain the true north and to make every effort so to perceive it. When the sun becomes visible the exploration of the city should begin from some point where the streets follow the cardinal points of the

<sup>6</sup> See Sidis and Goodhart, "Multiple Personality."

compass, or from which a general outline of the city can be obtained. The general rule would be to get acquainted with a strange place only when the usual stimuli by which we determine directions in practical life are most obvious and helpful, and to look about as little as possible at other times in case there is a tendency to illusions of direction. Everything depends on the early experiences in a new place, when associations which become basic are being established.

From the foregoing observations it would seem that one is justified in maintaining that in the waking state of consciousness a person is in a condition of tension of adjustment not only with respect to the more or less isolated objects of observation, but also with respect to their interrelations on a very extensive scale; that experiences are not each of a somewhat momentary and isolated character, but that they overlap in such a way as to call out comprehensive motor attitudes so that the effect of each stimulus is carried over in a cumulative manner not to be explained in terms of single neural pathways; that this cumulative motor attitude constantly comes into conflict with other such attitudes, bringing about certain confusions in orientation which may persist through life if their opposition is not reduced in the early stages of the association processes; and that these attitudes are kept up by the constantly recurring conditions of stimulation afforded by certain unchanging or slowly changing aspects of the physical and social environment. These motor attitudes<sup>7</sup> doubtless relax during sleep, but are again resumed on waking because of numerous direct and indirect stimulations similar to those of the previous waking state.

The writer has suggested in another article now in press,<sup>8</sup> that on the basis of this overlapping of the effects of individual stimuli we may explain the survival of the pleasant or successful acts in the process of learning over those that do not bring pleasure or success. Acts are not individual or discrete things, some of which survive as such while others are wholly eliminated. It is difficult to understand how the pleasurable "act" survives while the others are dropped off, unless one is willing to subscribe to the view that pleasure of itself

<sup>7</sup> Recently a number of psychologists have given more or less explicit attention to "attitudes," but usually of a more limited kind than those here studied. There is yet no general agreement as to whether such attitudes are ultimately analyzable into sensory elements or whether they are at times wholly motor and "imageless." Some writers have called them "conscious attitudes," while others, regarding them doubtless also as conscious, have used the term "motor attitudes." All writers seem to be at an agreement in regarding attitudes as being characterized by tendencies to response, whether as in "perceptual responses" or as in more overt activity. Of late it has been made plain that many acquired dispositions to certain types of responses are wholly unconscious.

<sup>8</sup> To appear in the *Psychological Review*.

"stamps in" the act which produces it. The difficulty lies in not understanding how an act can be emphasized by a successful result which follows it and which must, therefore, have a backward influence upon it. If responses overlap, forming larger unities, is it, then, not conceivable that no "act" is complete, in the higher organisms at least, until all responses of its own complex—*e. g.*, those directed toward getting out of a problem box—find expression together? May there not be mutual inhibition and delayed response until some consistent outlet involving mutual reinforcement is found by the trial and error processes? It is hoped that this hypothesis will tend to put the explanation of learning on a more objective and experimental basis than the conventional one of mere neural processes, often vaguely conceived or wholly hypothetical.

JOSEPH PETERSON.

UNIVERSITY OF MINNESOTA.

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## THEORY AS TRUTH: A STUDY OF THE LOGICAL STATUS OF SCIENTIFIC THEORY<sup>1</sup>

"Although in this long journey we miss the intended end; yet are there many things of truth disclosed by the way; and the collateral verity may unto reasonable speculations some what requite the capital indiscovery."<sup>2</sup>

THE greatest feats of science to-day—for science is the acquisition and communication of knowledge—are, I suppose, not its facts, much less its deeds, but in very truth its theories. The theories of modern science deal commonly with things that we can never hope to reach with our senses, with matters that are beyond the reach of immediate experience. To questions which have been under discussion through the ages, questions such as those of the atomic constitution of matter and the nature of light, science to-day in its theories gives perfectly definite answers. The nature of the case forbids that these questions shall be answered by facts. When the theories which answer them, however, are submitted to the scrutiny of logic, it appears that they are not hypotheses in any sense and that they have a certainty of the same order as that of *any bit of experience*. It is as certain that matter consists of atoms as it is certain that experiments can be performed in the laboratory—and the opinion that matter is made up of atoms is no guess: we may be as sure of it as we are sure that there is matter at all.

<sup>1</sup> The notions here developed were first worked out for Professor Royce's seminary, 1914-15.

<sup>2</sup> Sir Thomas Browne, "Pseudodoxia Epidemica," Book VI., Ch. 12.